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Editorial

Giant mineral deposits: Introduction

Giant, and to a lesser extent world-class, mineral deposits are the ultimate exploration targets, with discovery changing the financial bottom line of junior exploration companies and providing long-term resources and reserves for major mining companies. Despite this, there have been few volumes specifically devoted to giant mineral deposits, with most research papers dealing with their formation, and failing to identify critical genetic differences between the giant deposits and smaller deposits in the same deposit class. Some studies suggest there is a critical conjunction of a greater number of major controlling features for giant deposits when compared to smaller deposits. Certainly, GIS-based prospectivity or endowment studies of a number of orogenic gold provinces by researchers indicate that the giant deposits are the only deposits to satisfy all defined important components of the orogenic gold mineral system at the district or camp scale. However, such studies have not been conducted on other deposit groups to check whether this is a universal control on the uniqueness of giant ore systems.

In this special issue of *Geoscience Frontiers*, we assemble thirteen papers that address the geological, structural, geochronological, tectonic and genetic aspects of some of the giant to world-class mineral deposits across the world, with special emphasis on Asia where many giant ore systems are relatively poorly documented in the literature.

The first paper is by Groves et al. (2016) which discuss the factors that control the formation of giant gold provinces and deposits in non-arc settings. They identify critical lithospheric to crust-scale processes, and propose that contrasting and diverse mechanisms exert control on district to deposit scale. They also propose that a hierarchical approach is required to understand the conjunction of factors that result in giant gold provinces and gold deposits in non-arc settings.

Smith (2016) present a review of the large and giant deposits of rare earth elements (REEs) in alkaline igneous rocks and evaluate the processes of their formation from mantle to critical emplacement zones. They propose metasomatically enriched lithosphere as the magma source for REE deposits. The authors propose that weathering and supergene enrichment of carbonatite played a major role in the formation of the highest grade deposits such as those at Mount Weld (Australia) and Tomtor (Russia).

Fan et al. (2016) address the controversy over the genesis of the giant Bayan Obo REE-Nb-Fe deposit in China. Carbonatite dyke and dolomite at Bayan Obo are interpreted as products of mantle-derived carbonatitic magmatism at ca. 1400 Ma, likely linked to the breakup of Columbia. This giant mineral deposit witnessed two stages of mineralization. The REE-rich ore-forming magmatic-hydrothermal fluids are considered to be the principal contributor to the REE mineralization. Partial remobilization of REE occurred during hydrothermal events related to subduction of the Palaeo-Asian oceanic plate during the Silurian, resulting in the formation of vein-type mineralization.

Pirajno et al. (2016) evaluate the newly-discovered world-class Besshi-type mineral systems in the Palaeoproterozoic Bryah Rift-Basin, Capricorn Orogen, Western Australia in terms of their tectonic setting and geodynamic evolution and also report new Re-Os age data from the giant DeGrussa VMS deposit. They propose a revised lithostratigraphy for the Narracoota and Karalundi formations of the hosting Bryah rift-basin. An active narrow rift contains contemporaneous mafic intrusions, lavas and clastic sedimentary rocks that host the VMS systems. The authors invoke mantle plume activity and early stages of continental separation, with the formation of an oceanic plateau represented by mafic-ultramafic rocks of the Narracoota Formation, as the tectonic driving force for the mineralized province.

Vielreicher et al. (2016) provide an overview of the giant Kalgoorlie gold field which comprises two structurally-contrasting major ore types: the Fimiston- and Charlotte-styles. Both types have similar formation conditions and similar timing at ca. 2645 Ma, but formed in different structural scenarios which favoured giant deposit formation of the Fimiston-style ores in the Golden Mile. Gold was deposited due to wall rock reaction and phase separation within the ore fluid, with the tectonic driving force being a change in far-field stress related to changing plate motion. The supergiant orogenic district is correlated to the superior conjunction of more gold-critical factors than other deposits in the eastern Yilgarn gold provinces.

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Porter (2016a) presents an evaluation of the Oyu Tolgoi porphyry Cu-Au-Mo deposits of southern Mongolia within the Central Asian Orogenic Belt. The ore occurs as telescoped prograde porphyry, phyllic retrograde and high sulphidation overprints. The author identifies the key controls on the location, size and grade of the deposit cluster as: (a) a long-lived, narrow faulted corridor; (b) multiple pulses of overlapping intrusion within the same structure; and (c) enclosing reactive, mafic-dominated wall rocks, focussing the ore. Again, the conjunction of several critical magma and ore-controlling features appears critical.

Groves and Santosh (2016) evaluate the enigmatic Jiaodong gold province in East China as a key to propose a unified model for orogenic gold deposits. Existing global concepts that link the genesis of orogenic gold deposits with metamorphic fluids are equivocal. To explain Jiaodong within the global group of orogenic gold deposits, potential source of metal are the subducted oceanic slab with overlying sulfide-rich sedimentary package, or the adjacent mantle wedge. The authors recommend a holistic view with the Jiaodong province as a key constraint, where gold to form orogenic gold deposits is derived from late-orogenic metamorphic devolatilization of stalled subduction slabs and oceanic sediments throughout Earth history.

Yang et al. (2016) describe the Xincheng gold deposit as a specific example of a world-class gold deposit within the giant Jiaodong gold province in China. According to the authors, the major ore fluid is a medium temperature, CO_2-rich, and low-salinity metamorphic fluid sourced from depth that underwent phase separation at the depositional site to form high-grade gold shoots. They link the mineralization to dehydration and decarbonation of subducting Paleo-Pacific oceanic lithosphere, in support of the model of Groves and Santosh (2016) in the previous paper.

Porter (2016b) presents a review of the regional tectonics and magma chamber processes associated with the giant Jinchuan nickel-copper-PGE deposit of Gansu Province in China. The $\sim$0.83 Ga deposit is considered to have been emplaced during initiation of Rodinia breakup. The Ni-Cu sulphide ores occur in dunite cores of a large lherzolite sill. Parental picritic basalt magma was generated through high-degree melting of enriched sub-continental lithospheric mantle (SCLM) by an anomalously hot mantle plume, again emphasizing lithospheric processes involved in the formation of giant mineral deposit types. Extensive post-magmatic alteration modified the intrusion and mineralization.

Yudovskaya et al. (2016) address the origin gold mineralization in the giant Lena gold province of Siberia, including the giant Sukhoi Log deposit. The mineralization is structurally controlled and hosted in various sedimentary strata. Gold deposits occur in rocks which underwent prograde and retrograde metamorphism. Gold precipitation is considered to have occurred through mixing between aqueous and carbonic fluids. The timing of mineralization was broadly synchronous with early Palaeozoic metamorphism and orogeny.

Vakh et al. (2016) summarize the structure, mineralogy and genetic aspects of the anomalous Berezitovoe gold-polymetallic deposit in the upper Amur region of Russia. The deposit, located on the periphery of the Great Xing'an belt, preserves evidence for superposition of precious-metal mineralization. The action of late gold-bearing hydrothermal fluids on the early polymetallic ores and the selective mobilization of some elements is interpreted to have led to re-deposition with formation of complex sulphosalts in the ore bodies.

Kempe et al. (2016) investigate the giant Muruntau gold deposit of Uzbekistan as a unique case of an ancient hydrothermal system within the southern Tien Shan. They evaluate the various genetic concepts that include sedimentary, metamorphic, and magmatic processes in order to understand the formation conditions of the deposit, as well as absolute age relations between the various components. The authors also discuss the possible mechanisms that resulted in the extraordinary size of the Muruntau deposit, the largest orogenic gold deposit so far discovered globally.

Zhong and Li (2016) evaluate the multistage genesis of the giant Dongshengmiao Zn-Pb-Cu deposit in western Inner Mongolia. The authors classify the deposit as a SEDEX-type deposit that was remobilized during regional metamorphism. Large-scale remobilization resulted in redistribution of syngenetic sulfides, such that Zn-Pb-Cu sulfides that represent the orebody now show evidence for synmetamorphic and syntectonic mineralization. Copper mineralization is interpreted to have been overprinted on the syngenetic sulfides during metamorphic remobilization.

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